PLANTERS' BULLETIN

OF THE RUBBER RESEARCH INSTITUTE OF MALAYA

PLANTERS' BULLETIN THIRTYNINE

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Kuala Lumpur November 1958 Number 39

Editorial: Market Price

The mystery and intricacy of natural rubber price variation is a subject worthy of considerable study which we regret we have never had the time to attempt. Our ignorance and speculation concerning this matter have been greatly reduced by the appearance of a Government memorandum – 'Fluctations in the Price of Natural Rubber'.*

The purpose of the study was to determine whether and to what extent practicable measures could be taken to stabilise the price of rubber and whether such measures would benefit the natural rubber industry. The memorandum analyses the whole position of market price variation and sets out a number of factors both short term and long term, which affect the price of natural rubber.

Short term factors include irregularities in the amount of rubber produced and exported and in the quantities held in stock by consumer countries. Another is consumer buying policy. It is estimated that four American companies purchase nearly 70% of the natural rubber entering the United States and, with their subsidiary and related companies, probably account for 40% of that sold throughout the world. Similarly in Great Britain one large company is concerned with 50% of the rubber consumed in the United Kingdom. Thus the buying policies of only a few major businesses must have considerable affect on the price of natural rubber, particularly should any appreciable error arise in their estimation of factory requirements, thus causing sudden changes in the normal buying procedure.

The pamphlet also discusses the stabilising influence on rubber prices of synthetic rubber and concludes that synthetic rubber, over long periods of three years or more, tends to prevent very high prices for natural rubber being maintained.

Other factors considered are market operations and strategic stock piling, but the examination of measures which might be taken to reduce price fluctations does not produce any positive solutions. The conclusions reached are that price stabilisation should only be attempted if a level higher than that for synthetic rubber is required, and to do so would require a buffer pool and restriction of export, neither of which is desirable in the long term interests of natural rubber producers.

The memorandum does suggest that some of the causes of market price fluctuation could be removed or reduced, and thus give greater

* *'Memorandum on the Fluctuations in the Price of Natural Rubber' by P.F. Adams.*

price stability. We particularly endorse the recommendation that rubber statistics should be more comprehensive and up to date, but feel that the other recommendations – avoidance of sudden changes in export duties and foreign currency exchange policies, maintenance by consumers of larger stocks of natural rubber, closer relating of buying policy of consumers to their actual consumption requirements, greater 'hedging' facilities, prevention of excessive dealing – will not prove easy to introduce.

Rooting Habit

INFORMATION CONCERNING THE ROOTING HABIT of crops is required when considering many agronomic problems – fertiliser placement, cultivation practices, root disease, plant competition and correct land utilisation.

THE STRUCTURE OF ROOTS IN RELATION TO THE ABSORBING ZONE

During growth and maturation, roots undergo anatomical changes that affect their permeability to water and solutes. As the root matures, the walls of certain cells surrounding the conducting tissue become impregnated with impermeable substances, which hinder the passage of water and nutrients through them. The development of a cork layer on the older roots also hinders absorption, and although there are pores through which water and salts can enter the outer layers of the root, the transport of nutrients to the shoot is still restricted by the impermeable tissues surrounding the conducting vessels. Thus the chief absorbing zone of the root is in the younger regions where there are no impermeable tissues. In hevea, the absorbing zone of the feeder roots – the fine yellowish roots that ramify so freely through the soil – extends over at least the last six inches.

Since absorption occurs most readily near the root tips, plants that have extensively branched root systems ought to have an advantage over those that have sparse branching, especially when the soil is dry. It has been suggested, that the ability of pine to succeed where silver fir and spruce fail, results from the pine tree possessing twentyfour times as many root branches as the other trees have and eight times the absorbing surface. It might be suspected that differences in vigour between hevea clonal seedling families may be due to differences in their rooting characteristics, but a study of the rooting habit of nine families of clonal seedlings revealed no marked or characteristic differences in rooting habit between them.

The rate of growth of rubber roots was measured in a study of rooting in young clonal seedlings. Observations over many weeks showed that the rate of growth (or, rather, of elongation) was in the region of $1\frac{1}{2}$ inches to 2 inches per week. At times when the soil is dry, or when

the concentration of salts in the soil solution is too high, root elongation slows right down or ceases completely, and the feeder roots tend to dry up. Many workers have reported instances where woody plants possessing no living feeder roots were nevertheless able to absorb water and minerals through their old roots. When the fine feeder roots constitute only a small proportion of the root surface, as in many woody species, absorption through the thick old roots must therefore be of considerable importance.

MYCORRHIZA

A discussion of rooting habit would not be complete without mention of mycorrhiza, the symbiotic association between roots of many plants and fungi. For a brief account of this topic readers are referred to *Planters' Bulletin 12*, page 57. In hevea, mycorrhiza are difficult to find. Whilst their occurrence has been reported, there is no evidence at present to show that they play a major role in the nutrition of the tree. Though it is known from pot culture experiments that hevea grows well in sterile sand if supplied with the necessary nutrients, it is possible in soils with a high organic matter content that the ability of hevea to form mycorrhiza may be an important factor in the wellbeing of a plantation.

FACTORS AFFECTING THE DEVELOPMENT OF ROOT SYSTEMS

The manner in which a root system develops depends on its hereditary potentialities and on such environmental factors as soil moisture content, soil aeration, soil texture and structure, and on the nutrient content of the soil. To some extent the above ground environment affects root development, in that the vigour of the crown determines the amount of carbohydrates translocated to the root, but we shall not consider the above-ground factors here.

The environment of the root can be modified by drainage, irrigation, fertiliser applications and cultivations. When discussing water absorption and the ability of different trees to survive drought many workers have found it convenient to classify trees into those with strong deep tap roots and those with extensive, lateral roots. The rubber tree fits into neither category for it possesses both a well developed tap root and lateral roots, and is thus well adapted to exploit a large volume of soil.

SOIL MOISTURE AND AERATION

Roots will only grow in moist soils; when there is a lack of moisture in the soil the root hairs and the fine feeder roots quickly die. There is a widespread belief that roots can somehow detect water at a distance and can grow towards it. It is based on the observation that roots are concentrated in well watered areas of soil where the aeration is good. It is not generally realised that roots are continuously growing outwards in all directions from plants. Whenever these roots, extending at random,

reach an area where there is an abundance of moisture as well as good aeration, they branch profusely. It is not that they actually grow towards moist soil from dry soil. In fact, the roots of many plants will grow downwards out of moist soil into dry soil until further elongation is stopped by desiccation, instead of turning back to keep in the moist soil.

Soil moisture affects root growth not only directly but also indirectly, because it affects soil aeration. Flooding apart, problems of excessive soil moisture are really problems of poor soil aeration. In a waterlogged soil the channels or pores between the soil particles are filled with water, thereby restricting the diffusion of oxygen into the soil and of carbon dioxide out of it. Soil aeration affects roots through three factors; the oxygen content of the soil air, its carbon dioxide content, and the content of the products of anaerobic decomposition, such as hydrogen sulphide. Root development appears to be adversely affected if the oxygen content of the soil falls below 10% and to stop altogether when there is less than about 5% of oxygen. The absorption of nutrients by roots is an active process which requires a supply of oxygen. A few specialised aquatic plants, such as rice, have air channels inside their roots through which oxygen can pass from the shoots above ground to the roots; such plants are less dependent upon the oxygen content of the soil.

All roots are killed by high concentrations of carbon dioxide, but may tolerate about 10% for short periods. However the concentration must be much lower for optimal root growth, probably less than 1%. The effects on roots of the products of anaerobic decomposition has not been studied in detail. Hydrogen sulphide, which can be detected in the subsoil of many coastal clays, is toxic to most plant roots in low concentrations. Where poor soil aeration is a limiting factor, growth can be improved by draining, lowering the water table, and allowing free diffusion of oxygen and carbon dioxide. If the soil pores are small or if they are blocked with silt particles, as is the case in some of the very heavy coastal clays that have a cheesy texture, cutting extra drains may only partially improve soil conditions. For a further discussion of soil drainage reference should be made to *Planters' Bulletin 28*, pages 20 to 22.

SOIL TEXTURE AND STRUCTURE

The adequacy of soil aeration depends largely on soil texture and structure because gas exchange occurs through the larger pores which are free of water. Aeration is never a limiting factor in sandy soils, but it is quite often inadequate on fine textured soils, particularly if they are poorly granulated.

Roots only grow freely in soils which possess a structure loose enough for them to penetrate easily. Roots cannot penetrate hard ironstone concretions or pans except through existing channels and cracks, nor can they ramify freely in hard compacted soils. This is particularly the case

in clay soils where puddling and subsequent compaction have taken place; root development is restricted in such soils to cracks and pores existing between the clods of clay, caused by the decay of old roots, or by the activities of soil fauna.

MINERAL NUTRITION

Though the application of fertilisers encourages root growth, the effect of fertilisers on root growth is mainly indirect. The direct effects of fertilisers are usually on the rate of leaf growth and of carbohydrate production, making more carbohydrates available for translocation to the roots for growth. The increased root range consequent on the addition to the soil of a nutrient that is in short supply will enable the plant to make better advantage of the other available soil nutrients.

EXTENT OF THE ROOT SYSTEM IN RUBBER

Information concerning the spread of rubber roots is required for two reasons. Firstly, to provide a better understanding of fertiliser placement. When a fertiliser is applied to a free draining soil, the nutrients, if not absorbed by the roots will in time be leached through the soil to a depth below the limit of root penetration. It is reasonable to assume that the proportion of fertiliser absorbed will be related to the area of root surface in the soil through which the nutrients pass.

Secondly, a knowledge of the root spread of young trees may influence policies of cover control, and the inter-planting of crops with rubber. It is desirable to know where and when competition between rubber and covers or other crops is to be expected. Competition for water and nutrients will also depend on the rooting habit of the cover plants.

Figure 1. A three year old tree, of which some of the lateral roots extended for 30 ft (see Figures 5 and 6).

A not uncommon belief is that the area covered by the canopy of the rubber tree is the same as the area of root spread. This is far from true, the root spread of young rubber is often much greater than the spread of the canopy. Lateral roots have been found on many occasions to spread through adjacent planting rows, those lying close to the soil surface attaining the greatest horizontal spread. Work on forest trees

Figure 2. A two year old tree with root system partially exposed: note the lateral roots extending into the covers. See Figures 7, 8 and 9 for further illustrations of the root system of a two year old tree.

has shown that it is common for roots to extend well beyond the periphery of the canopy.

Although thick roots may play a part in the absorption of water and nutrients, the most efficient zone of absorption is near the root tip; therefore the number of tips and the number of fine, so called feeder roots, are important factors. With this in mind a study of the horizontal distribution of the surface feeder roots of rubber, made by taking soil core samples at different distances from the trees, was carried out over a range of soil types on trees varying between one and twentytwo years old; trees in rows twenty feet apart were studied.

Up to three years old it was found that the roots were concentrated close to the trees. At or about four years after planting the feeder roots of adjacent rows had met. With trees of five to seven years old it was found that the root density was significantly greater in the centre of the inter-row area than close to the tree. It is to be noted that the high concentration of roots observed in the centre of the inter-row area was the result of root growth from two rows of trees and not one. Assuming that each row makes an equal contribution to this root concentration, the root concentration in the centre of the inter-row resulting from one row

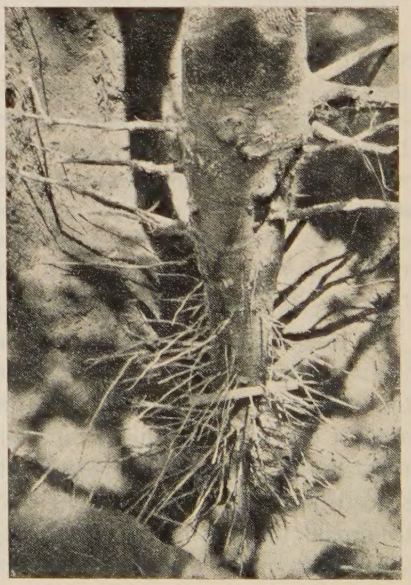


Figure 3. The tap root of a seven year old tree showing the profuse development of lower laterals, which were growing down to a depth of 4 ft. Many of the lower laterals in the bottom right of the picture were cut during excavation.

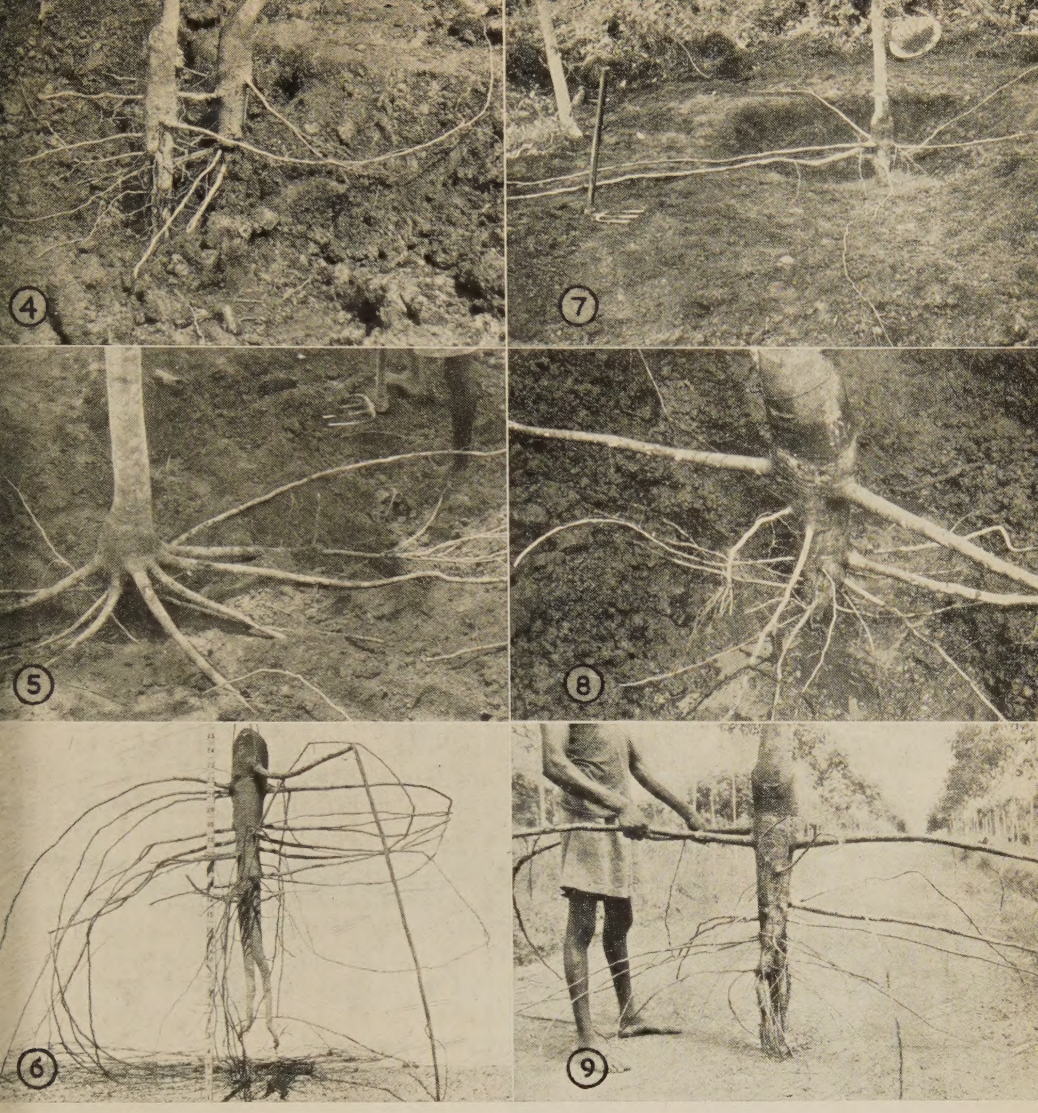


Figure. 4. The root system of a tree one year old showing fine lateral and feeder roots growing well below the soil surface. The length of the longest lateral root was 6 ft.

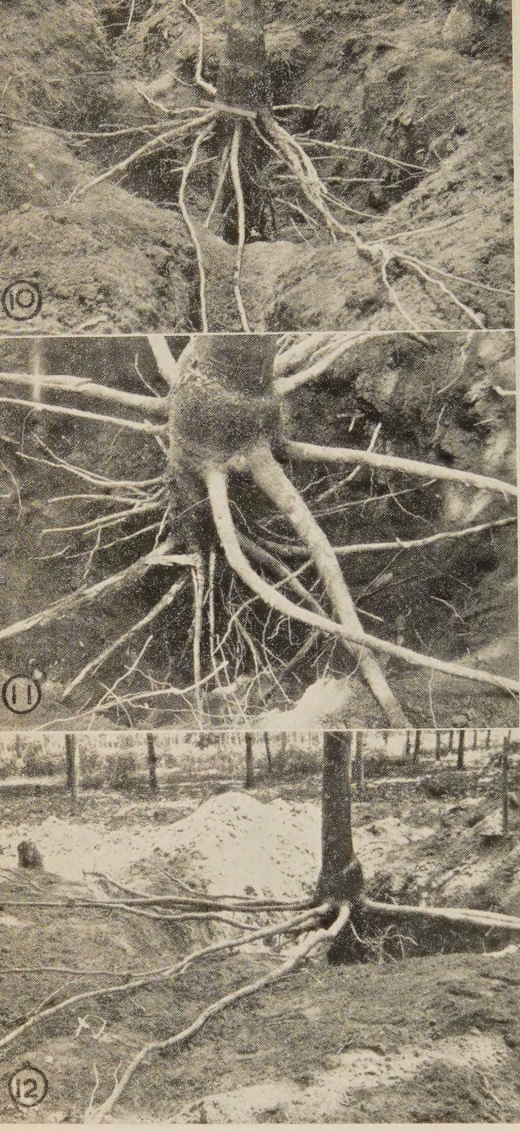
Figure 5. The exposing of the surface lateral roots of a tree three years old. Note the development of fine roots from the laterals.

Figure 6. The excavated root system of a tree three years old (see Figure 1 for illustration of the tree) showing the strong development of both the tap root (5 ft long) and the lateral roots, some of which extended 30 ft. Note the thick lateral roots arising from the tap root down to a depth of 2 ft.

Figure 7. The root system of a tree two years old after exposing the lateral roots which can be seen extending well into the covers.

Figure 8. Exposed root system of a tree two years old: note the development of lower lateral roots. (see Figure 9 for the excavated root system of this tree).

Figure 9. The excavated root system of a tree two years old showing good development of lower lateral roots.



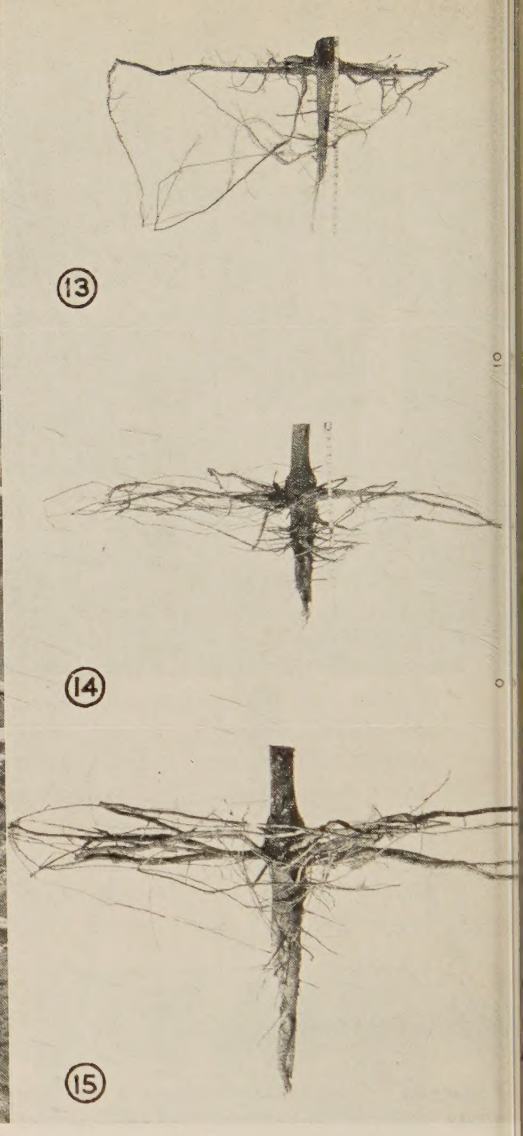


Figure 10. Exposed root system of tree seven years old in hedge row planting: note the weak development of surface laterals some of which are growing along the planting row. Figure 3 shows the profuse development of the lower laterals on this tree, whose tap root was 8 ft long.

Figure 11. Lateral root growth in tree five years old: note the profuse development of the lower laterals. See Figure 14 for the excavated root system of this tree.

Figure 12. Exposed root system of tree eight years old showing the very strong development of the surface lateral roots. See Figure 15 for the excavated root system of this tree.

Figure 13. Excavated root system of tree four years old showing the tapering tap root 6 ft long.*

Figure 14. Excavated root system of tree five years old: note the strong development of lower lateral roots.*

Figure 15. Excavated root system of tree eight years old showing the strong development of the tap root (8 ft long) and of the lateral roots.*

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* *In order that the root systems, illustrated in Figures 13, 14 and 15, could be photographed the whole root was inverted. Thus a few roots appear to be growing vertically from the lateral roots. The scale on Figure 14 refers to Figures 13, 14 and 15.*

was roughly the same as the concentration close to the tree; in many cases the concentration was greater close to the tree.

In areas of mature rubber, fifteen years old or older, the root density across the inter-rows was found to be fairly even and not significantly related to distance from the trees.

In general it would appear that, after roots from trees in adjacent rows have met, a ramification of the roots takes place the final result being that there is little variation in the concentration of surface feeder roots with distance from tree in mature rubber. It will readily be appreciated that the pattern of root development just described will be subject to many variations due to such factors as soil type, soil moisture, aeration, cultivation, nature of covers and method of fertiliser application, but in general it would be expected that root development in hevea will follow this pattern.

In further excavations of the root system of trees (all RRIM 501) one to eight years old (from cutting back), certain observations have been made on the distribution of rubber roots. The root systems of some of these trees, growing in light soils at the Institute's Experiment Station at Sungei Buloh, are illustrated in *Figures 2* to *15*. The strong development of both the tap root and the lateral roots in rubber was clearly demonstrated (*Figures 6, 9, 12, 13, 14, 15*). Tap roots five feet long have been observed on trees only three years old (*Figure 6*) and lateral roots twenty to thirty feet long have been traced from trees of the same age. In older trees (seven and eight years old) tap roots eight feet long (*Figure 15*) and lateral roots over thirty feet have been excavated.

One very interesting feature of the rooting habit of rubber that was revealed was the observation of lateral roots well below the soil surface (*Figures 3, 4, 6, 8, 9, 10, 13, 14, 15*). Lateral roots were by no means confined to the surface layers of the soil. The difficulties of excavation precluded the determination of the length of these lower laterals. However their very existence well below the surface shows that the soil conditions were such that good root growth was possible, and therefore that the fine feeder roots which arose from them would be capable of absorbing nutrients.

It was often observed that the surface lateral roots tended to grow slightly downwards. This observation and the demonstration of the lower laterals suggest that conclusions drawn from studies of the surface roots only should be made with caution. Especially is this so when discussing fertiliser placement in relation to surface root concentration. It is often envisaged that the root system of rubber consists of a deep tap root, and shallow lateral and feeder roots only; that this is not the case is clearly demonstrated in *Figures 6, 9* and *14*.

CONCLUSIONS

The main object when applying soluble fertilisers is to spread them in such a manner that they will eventually come into contact with the greatest possible number of roots.

For young trees where the feeder roots are concentrated close to the tree, the normal method of applying fertiliser in the clean weeded planting row area is satisfactory.

For trees five to seven years old, it would appear, on theoretical grounds, that there would be an advantage in applying fertiliser in a strip down the centre of the inter-row area. However this advantage will be very small when it is remembered that the area of the manured strip is more important than the position of the strip in relation to the tree rows. Furthermore studies have shown that lateral roots can develop well below the soil surface and that fine fibrous roots develop from these lower laterals. There is no reason to suppose that these lower roots are less efficient absorbers of nutrients than the surface feeder roots, provided the soil is not waterlogged and soil aeration is satisfactory. Thus the concentration of feeder roots in the top two to three feet of soil, close to the tree, may be considerably greater than in the centre of the inter-row area. The lower feeder roots close to the tree may be important in absorbing nutrients that have been leached out of the top soil; in the centre of the inter-row area few such lower feeder roots are present. For these reasons we consider that the most suitable and convenient method of applying fertiliser to rubber of this age, when a cover of leguminous or upright indigenous growths has persisted in the inter-row area, is to apply it broadcast in the planting rows; the elimination of a good type of ground cover by spraying, merely for the purpose of manuring, would certainly not be an advantage. However, where there is no ground cover, or where the cover consists of grasses, we recommend that the fertiliser be broadcast in the inter-row areas after spraying out the cover with a suitable herbicide.

In mature areas with no cover plants present, the fertiliser should be broadcast to cover as large an area of the ground as is conveniently possible. In terraced areas the application must be restricted to the actual terraces, to avoid fertiliser being washed down the slope, but the presence of the lower laterals spreading from the tap root will ensure satisfactory uptake of any nutrients washed through the topsoil layers.

Fertiliser Nomenclature

Our editorial in *Planters' Bulletin 24* advocated changing the method of quoting the content of nutrients in fertilisers – as the percentage of the element, instead of as the oxide. Nitrogen content is already so given. The proposed change would mean defining the content of K(potassium) instead of K_2O; and of P(phosphorus) instead of P_2O_5.

The arguments for making the change are still valid, and are generally agreed; but, while the countries from which fertilisers come to Malaya retain the old system, to adopt a different one here would inconvenience importers. For this reason the changeover that we advocated has been indefinitely postponed.

Establishment and Maintenance of Legume Covers

THE ECONOMIC ASPECTS of the cultivation of cover plants grown in association with rubber are the subject of much controversy in planting circles at present. The establishment of legume covers has been previously described, in *Planters' Bulletin 14*, but the time is thought opportune to present a further discussion on the matter. From the outset it must be realised that there is no cheap way of establishing and maintaining a cover of leguminous creepers. Preparation of the seed bed, sowing and selective weeding are all expensive operations, but their cost is justified by improved tree growth and soil fertility. Despite these benefits the cultivation of leguminous creepers can become economically unsound if unsatisfactory planting and maintenance techniques are used. The biggest trouble that the planter must contend with in growing these covers is the ease with which they can be invaded, and eventually displaced, by grasses and *Mikania scandens*. To keep these unwanted plants out, and so retain the economic practicability of the whole operation, three basic points need to be emphasised; they are:

1 Grass and *Mikania* should be eradicated before sowing the legumes.

2 The seed should be a mixture of leguminous creepers, and sown at a liberal rate to obtain a rapid covering of the soil.

3 Unwanted plants should be weeded out by hand for at least eighteen months after sowing.

If these principles are adhered to, sown leguminous creepers can be expected to develop into a vigorous cover that will last for perhaps up to four years, and give maximum returns for the money and effort put into their establishment. In what follows we discuss in more detail the methods involved.

PREPARING THE GROUND

It is essential that grass, *Mikania* and other unwanted plants such as Siam weed, Straits rhododendron, and maiden-hair creeper should be eradicated before the covers are sown. In jungle clearings the work will consist of selective weeding among the indigenous plants as they regenerate. In lalang and belukar areas, that have been cleared either mechanically, with ploughing and harrowing, or by hand felling and spraying, and in old rubber plantings that have been mechanically cleared and cultivated, there should be no weeds at all growing immediately after the clearing. Where old rubber is to be poisoned, grasses should be sprayed out before the tree poisoning is done, while they are growing only thinly. In plantations that are to be felled and burned, the grasses and other weeds should be sprayed out before felling and then, when the ground has been cleared, given an additional spraying immediately

prior to sowing the legumes. In all cases the aim should be to time the various operations so that the soil surface is exposed for the minimum of time between eradication of the old cover plants and establishment of the legumes. This will prevent grasses from establishing themselves and avoid an expensive weed control problem, and minimise deterioration of the surface soil physical condition, particularly in mechanically cleared areas.

A practice which has commonly been followed, and which we do not recommend, has been to sow the legume seed along strips clean sprayed with sodium arsenite through the grasses and weeds developing in the cleared area. As the cover plants developed so the weeds on either side of the strip were sprayed out or hand-pulled in advance of the spreading creepers. The objections to this method are the difficulty, and therefore expense, of weeding the grasses thoroughly by hand, or, if spraying is done, the risk of damaging the sensitive young legumes by spray drift. A pure leguminous creeping cover cannot be readily obtained in this way, and it is more likely that some amount of grasses will persist amongst it, to develop and swamp out the legumes in a comparatively short time.

SEEDING METHODS

Seeding methods will vary according to individual circumstances but should all be directed towards obtaining a complete ground cover in the shortest possible time after the ground has been cleared. In old rubber areas where the trees are to be poisoned, the legumes can be sown as soon as grasses have been sprayed out and the trees poisoned. The legume seedlings will root, and although their growth will be weak while the trees retain their leaves, they will develop vigorous growth as soon as these fall and the shade goes. In all other plantings, whether mechanically cleared or not, the cover plants should be sown as soon after clearing and lining as planting conditions permit. The actual time of sowing involves judgement on the part of the planter. It is tempting to put off sowing until a period of wet weather is assured. However as such a period is also conducive to the rapid establishment of grasses, and to surface water run-off which may wash the seeds from the ground, there is much to be said for sowing the cover plant seeds immediately after clearing, even though ground conditions may be dry. Under such conditions the seed should not be pre-treated, but only inoculated with Rhizobium and dried before sowing. Some of the seed will develop fairly quickly and develop sufficient growth, supported by dew and occasional rain, to nurse the ungerminated seed into growth as soon as moister soil conditions prevail. There is the risk that a period of drought may be experienced when the young seedlings will suffer badly from desiccation and insect attack; where such periods can be forecast from local experience they should clearly be avoided.

Opinions vary as to methods and rate of sowing and the type of seed to be used. Some planters prefer to sow the seed in small pockets or basins rather than in drills, which is more usual. In mechanically cleared areas broadcasting is sometimes preferred. Some planters have successfully sown pure covers of *Pueraria phaseoloides*, at a seeding rate of about 2 lb/acre, while others (the majority) prefer to use mixtures of this creeper with one or both of the creepers *Calopogonium mucunoides* and *Centrosema pubescens*, sown at rates varying between 4 and 10 lb/acre. Sometimes legume bushes such as *Flemingia congesta*, *Crotalaria anagyroides* and *Tephrosia candida* are included as well, and *Desmodium ovalifolium* is also sometimes used, planted as seed or cuttings. Success is possible with all the above systems, but in general a vigorous cover can most quickly be obtained by using a mixture of *Calopogonium mucunoides*, *Centrosema pubescens* and *Pueraria phaseoloides* (5 : 4 : 1 or 2 : 2 : 1), sown in drills at the rate of 5 to 7 lb/acre. We favour using a mixture of the three leguminous creepers on the grounds that advantage can be taken of their different virtues. *Calopogonium* develops most rapidly during the important first few months after sowing, but it does not persist as a strong growth for more than about eighteen months. *Pueraria* will provide the bulk of the cover during the second and third years after planting, whilst the *Centrosema* will persist for longer than the other two covers under the developing rubber. The use of a mixture of seeds also provides some insurance against poor germination of any one; for instance a poorly germinating batch of *Pueraria* seed may be able to develop vigorous growth in the presence of the other two creepers, whereas if sown on its own it may only grow thinly and with insufficient vigour to resist invasion by grasses and *Mikania*.

Flemingia is a useful bush to plant with the creepers. It provides support for the creepers to climb, and it is a deep rooting legume which will both fix nitrogen and play a useful role in maintaining nutrient circulation in the soil. In addition it tolerates light shade. The low, shrubby *Desmodium* can also be useful, as it is a cover which will not encroach too vigorously into the planting rows during immaturity and which will persist into the period of maturity of the rubber trees.

To obtain a rapid development of the cover, we would prefer to sow the seed in two or preferably three drills running down the inter row areas. Drills are to be preferred to pocket planting because the covers are likely to spread outwards more rapidly from a thin row than from a circle or pocket, and it is rather easier to weed between rows than between scattered patches. In both methods there is danger in sowing the seed so densely that the young seedlings choke each other and are unable to develop vigorous creeping lateral stems. A seeding rate of 5 – 7 lb/acre, sown in several drills down the inter-row areas, is low enough to avoid this choking effect and yet still produce sufficient seedlings to ensure rapid development of the cover. Except when sowing

during a dry period cover plant seed should be pre-treated, inoculated and sown mixed with an equal weight of rock phosphate. The pretreatment is necessary because a proportion of the seeds of many legumes are what is known as 'hard'. 'Hard' seed absorb water very slowly and will not germinate for several months or even years unless given special treatment. In a note on page 134 a description of pre-treatment methods is given.

MAINTAINING THE COVER

The object of maintenance operations must be to stimulate and maintain the most vigorous possible growth of the legumes, and to keep out for as long as possible all invading weeds which might threaten to spread and displace the legumes. There can be no half measures in the operations. Without maintaining a weeding routine which can effectively keep grasses and *Mikania* under control, the legume creepers cannot be kept pure for more than a few months and the expense of their establishment may be largely wasted. For at least the first twelve months, and preferably the first eighteen months, after sowing, we recommend that selective hand weeding rounds should be carried out as often as conditions require. At the end of eighteen months the covers should be so thick and vigorous that regular monthly rounds of selective hand weeding should be sufficient to maintain the purity of the covers, without difficulty, for a further two years. During the first eighteen months the covers should be dusted with rock phosphate at the rate of $\frac{1}{2}$ cwt/acre at intervals of three or four months. After this time, one or two cwt/acre of rock phosphate should be applied annually to maintain the vigour of the legumes.

The legumes should persist for at least three years from planting under most conditions. Beyond this their persistence will depend upon the amount of shade cast by the rubber trees. In a hedge planting the covers may remain strong for another year or two, but with the more usual rectangular plantings the covers will progressively weaken after about the third or fourth year from sowing. At this stage it becomes impracticable to maintain the purity of the covers, and if grasses have become strongly established they must be controlled by routine spraying.

Our recommendation for the control of covers in the planting row is that the strips should be hand weeded and kept clean for the first twelve months after planting rubber seedlings or stumps, and up till six months after budding in the field. Where circle weeding is practised instead of strip weeding, during these initial periods after planting, the covers compete strongly with the rubber for soil moisture and nutrients, with the result that trees growing in clean weeded strips grow better than those which are circle weeded. After the initial period, however, there it little to choose between the two systems in terms of growth, as the rubber trees are rooting extensively under the covers in both instances.

We recommend that circle weeding should then be introduced. There are two reasons for this. Firstly that soil wash along the planting row is prevented; and secondly, that the system involves the minimum of interference with the cover. In strip weeding systems, the continued checking of the creepers along the boundaries of the strip opens the way for invasion by grass. This is particularly so when spray weeding is carried out, for legumes may be killed at some distance in from the edge of the strip by spray drift damage, and the way is left open for invasion by grasses which are less sensitive. For the same reason we do not recommend spot spraying of grasses in legume covers, for the legumes suffer a greater check, and regenerate less quickly, than do the grasses. The disadvantages of circle weeding are that frequent rounds of ring raking are required, under good growing conditions, to prevent the creepers from climbing the rubber trees, and that movement and supervision in the area are impeded. On steep land circle weeding may be preferred for its more effective restriction of soil erosion, but for general convenience strip weeding has some advantage. Some planters compromise by allowing the covers to spread over the planting row only at intervals of several points. In either of the latter two cases, however, the risk of invasion by grasses along the edge of the planting strip must be accepted.

Under the circle weeding system, fertiliser dressings for the rubber can for some time be applied satisfactorily to the clean weeded circle itself; but, as the size of the dressings increase, there is a danger of scorching the tree if this system is continued. The danger is avoided by broadcasting the fertiliser over the covers in the planting row. There is no need to spray the covers first, as the fertiliser itself will scorch their leaves to some extent; whatever fertiliser is taken up by the creepers will eventually be returned to the soil and become available to the rubber. The principle, once again, is to disturb the cover as little as possible, to minimise the risk of invasion by grasses.

Though we do not recommend spot spraying of grasses in leguminous creeping covers, spot spraying of *Mikania* with a selective herbicide is advised (*Planters' Bulletin*, 38, page 113). The invasion of legume covers by *Mikania*, once a most difficult problem, can now be checked by using Fernoxone. Combined with the cultivation measures described above, aimed at minimising the risk of invasion by grasses, the use of Fernoxone should enable the planter to maintain the purity and vigour of his covers for some years.

Without a doubt it is expensive to implement the measures described above. However, carried out properly, they can ensure that a satisfactory ground cover is obtained. When their cost is considered in relation to the improved tree growth that can result, they may well prove more economic than other systems of cover plant management designed for short term economy.

Pretreatment of Leguminous Cover Crop Seeds

THE PROPORTION OF HARD SEED which will not germinate for a long time varies considerably. Of the species commonly employed, rarely less than half the seed is hard, usually three quarters or more, sometimes all of it. The proportion of hard seed appears to be largely determined by uncontrollable environmental conditions when the seed is harvested. However, storage under damp conditions may increase the proportion of hard seed in *Pueraria phaseoloides*.

For good field establishment using the recommended seeding rates, it is estimated that one quarter of the seed should germinate without pretreatment within three weeks, when sown in moist soil or on damp blotting paper.

The seed may be tested as follows. A sample is drawn by mixing together pinches of seed from different parts of the bulk lot – from the centre and sides of the top, middle, and bottom of the bag or bin. Sow a thousand or more seeds on damp blotting paper in an earthenware dish. The seed must be kept damp, and covered with another dish or piece of glass so that vermin cannot carry it off. If the germination is less than 25% within three weeks, consideration should be given to pretreating the whole or part of the seed, or increasing the seeding rate.

Pretreatment with sulphuric acid is the most effective method, but it requires strict supervision because of the dangerous nature of the acid and hence usually is suitable for small quantities of seed only. The seeds are placed in a large glass or earthenware vessel, concentrated sulphuric acid weighing one twentyfifth of the weight of the seed is added and stirred in rapidly with a glass rod.

The optimum periods of treatment are:

for *Calopogonium mucunoides* and *Centrosema pubescens*	- 15 minutes
for *Desmodium ovalifolium* and *Flemingia congesta*	- 20 minutes
for *Pueraria phaseoloides*	- 30 minutes

However, batches of seed vary and, while excess treatment is harmful, less than the optimum period still gives considerable benefit. Furthermore, with large quantities it is hard to add water quickly enough to wash away the acid and stop its action. It is therefore advisable to halve the figures given above, and to use the lowest figure for mixtures.

A large excess of cold water is added quickly, to avoid spitting of the acid, repeatedly changing the water by decantation or by continuous flow. The period of washing should be about three hours after which excess water should be drained off and the seed sown at once.

The alternative treatment is to use hot water. There are two ways of doing this:

a Prepare a supply of hot water at about 75°C (165°F) by mixing two parts of boiling water with one part of cold water. Pour it over

the seed, stirring all the time. After leaving it for two hours to cool down, drain off the excess water and allow the seed to become dry enough to be easy to handle.

b Place a bucket of water in a smokehouse at about 50° (120°F). When the water has reached this temperature, pour it over the seed and leave the seed immersed in the hot water in the smokehouse. After six hours, remove the bucket, pour off the excess water and surface dry the seed.

These recommendations differ from those given in *Planters' Bulletin 14* page 88 in reducing the periods of soaking, which can cause damage. Hot water pretreatment, though less reliable than acid pretreatment, is easier to carry out.

Because pretreatment forces the seed to germinate whether or not there is water in the soil, it increases the danger of failure through drought. Until other methods of pretreatment with less risk have been perfected, the current methods should be applied only when a favourably wet season can be expected to continue.

Inoculation with a *Rhizobium* culture ensures that the nitrogen fixing bacteria are present at sowing. Instructions are given with the packets of compost that are supplied by our Pathological Division.

Since it is easier to inoculate seed which has not been pretreated to increase its germination rate, and moreover there is the risk of loss during drought with pretreated seed, a useful compromise is to pretreat half the seed and to inoculate the other half, mixing the two lots thoroughly before sowing.

Low Volume Sprayers

THE TERM LOW VOLUME may be misunderstood when used in spray applications and therefore, before discussing the use of low volume equipment, it is essential to define the term as used hereafter.

Low volume spraying describes a method whereby a small volume of the solution, usually at high concentration, is applied. The quantity used may lie within the range of 1 – 50 gallons per acre.

In the range 20 – 50 gallons per acre most of the low volume tractor mounted sprayers designed for weed control are found. These are low pressure machines and achieve low output through the use of critically designed nozzles. In the range of 1 – 5 gallons per acre are found machines usually classified as mist blowers and fogging machines whose use has been designed for bush and tree crops. However, all mist blowers are not low volume sprayers and indeed some of the largest output sprayers are the mist blowers used for the application of insecticides in commercial orchards; sprayers of such size that their use in rubber cultivation could never be considered.

Low volume spraying is a much more exacting operation than high volume spraying – the low volume application posing problems on coverage which do not arise in the latter case. Fortunately, this is not a problem for the person using the sprayer but for the designer, who has had to produce a nozzle giving a low output and small drop size or, as in the case of low volume mist blowers and fogging machines, produce other means of breaking up the spray stream into small drops and carrying it to its target.

The main attraction of low volume spraying is the reduction of the quantity of water or other carrier used per acre. Whereas in high volume applications sufficient carrier is sprayed to ensure a thorough wetting and drop size is of secondary importance, in low volume spraying drop size is the critical factor, the aim being to get discrete individual drops to cover all surfaces. This ideal is extremely difficult to achieve with nozzles, but is more easily obtained with fogging machines and mist blowers. While the low volume is the chief advantage of such spraying, difficulties may be encountered in getting the high concentrations of active ingredient into solution, and the selection of formulations suitable for low volume spraying will be somewhat restricted. In the use of extreme low volumes of say 1 to 5 gallons per acre, oils rather than water are usually preferred as carriers because oil has much better spreading properties and evaporation of the smaller drops used is less.

With the exception, therefore, of fogging machines and mist blowers, the main component of a machine making it low volume is the nozzle. Nozzles are now available for ordinary knapsack sprayers with low outputs which put them into the category of low volume sprayers, but their use would appear restricted on estates.

BOOM SPRAYERS

Possibly the greatest use of the low volume technique, in the range 20 – 50 gallons per acre, is for mechanised spraying against weeds, for which the sprayer is tractor mounted with a wide boom and is therefore not generally applicable to conditions on Malayan estates. It has been reported that successful spraying has been carried out locally with these units for lalang spraying, and there may be certain situations where cover spraying could be undertaken. The relative merits of any form of mechanised spraying will however depend on ground conditions.

The equipment, typical of this type, shown in *Figure 1* was used at the R.R.I. Experiment Station to apply 12½ lb sodium arsenite in 25 gallons of water per acre. Trouble was experienced from continual blocking of the fine nozzles, leaving strips of unsprayed lalang, and drift of spray on to neighbouring trees.

MIST BLOWERS

In this type of sprayer the standard form of nozzle is dispensed with and there is no pressure to atomise the spray fluid. A large volume of

air is generated, into the stream of which the liquid is injected, thus breaking up the spray into small drops. Sprayers of this design produce a volume of air sufficient to carry the spray direct to its target. Although mist blowers are generally used in this manner they can also be used for drift spraying. Fogging machines on the other hand are not strictly 'aimable' and depend on air movement to secure coverage.

Figure 1. Spraying grasses with sodium arsenite solution from a 12 nozzle boom supplied by a tractor-mounted unit driven by the power take-off. Sacking shields hang at the end of the boom to reduce the danger of spray drift.

Mist blowers would seem to offer the best means of low volume spraying on rubber estates, being suitable for treating covers, nurseries and immature trees. The larger equipment necessary to reach the top of mature trees would not appear to have a use in Malaya although such machines have been used in Ceylon against *Oidium*. A small wheel-barrow model has been used for spraying nurseries and smaller trees in Malaya (*Figure 2*) and is capable of giving satisfactory coverage with volumes as low as 3 gallons per acre. Recently, knapsack machines with miniature engines have been produced (*Figure 3*) and these have sufficient throw to treat trees 5–7 years of age.

Figure 2. A miniature mist blower capable of treating trees up to a height of 30 feet.

FOGGING MACHINES

These work on the principle of vaporising the solution to be sprayed in a hot stream of air giving a fog which condenses on leaving the outlet. This fog, composed of the finest drops, is completely 'non-aimable' and successful operation depends on its dispersal by drift and wind currents. A development of this principle is used in the fogging machine shown in *Figure 4* where a pulse jet is used to provide a wave front

Figure 3. Legume covers being sprayed with DDT emulsion by means of a knapsack mist blower.

to carry the volatilised solution. Such machines require specially formulated materials for their successful operation.

Fogging machines have been used on estates for mosquito control in buildings and in a few cases have successfully applied insecticides to covers. It is possible that their use can be extended along this line as ground coverage is rapid where large areas are concerned but the one great drawback to their use in the field is the need to have suitable weather conditions as the dispersal of the fog depends on air movement. This movement must be just sufficient to distribute the spray within the crop but not strong enough to carry it through or above the plants. Different conditions are required for the treatment of different crops. It is not considered that fogging machines would give as good results in nurseries or to plants in the field as mist blowers or knapsack sprayers fitted with low volume nozzles.

KNAPSACK SPRAYERS WITH LOW VOLUME NOZZLES

There are available on the market a number of low volume nozzles which can be fitted to the lance of the ordinary knapsack sprayer (*Figure 5*). These will enable complete coverage to be obtained down to approximately 5 gallons per acre at a normal walking speed. Although such a set-up provides a cheap low volume sprayer, the area that can be treated with it in a day is smaller than with a power operated mist blower or fogging machine. However, the small cost of the equipment is an attraction and it will perform equally well for

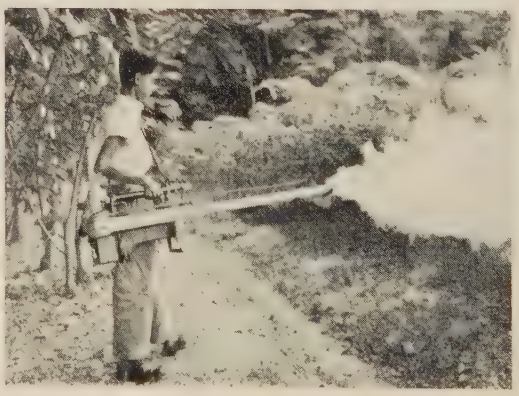

Figure 4. A fog-generator being used to treat a nursery with an oil soluble copper compound in an experiment to test the effect of oil-based copper fungicides in the control of bird's eye spot.

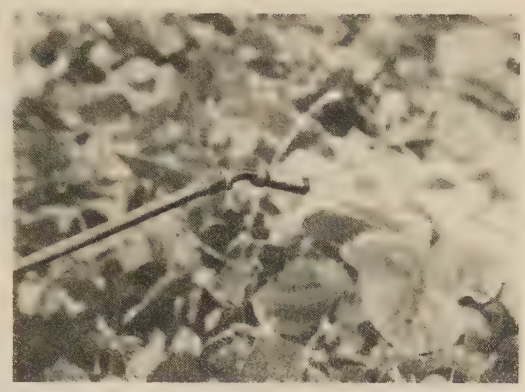

Figure 5. A low volume nozzle fitted to the lance of a pneumatic knapsack sprayer being used to spray cover.

spraying grasses, covers, or nursery plants.

AERIAL SPRAYERS

No account of low volume sprayers is complete without mention of aerial sprayers. It is unlikely however, that an individual estate would ever be called on to organise aerial spraying.

Although the low volume output used in aerial spraying is more the result of speed of coverage and not actual output, aerial spraying is an extreme example of low volume spraying. Of necessity it must be so, as the cost of carrying large quantities of spray material would make the method quite uneconomical.

Aerial spraying equipment may consist of a boom with nozzles, or the spray may be discharged from rotating brushes or spinning discs. Where a spray boom with nozzles is used the spray material is pumped to the boom either by an internal electric pump or external wind driven pump. The power to rotate the brushes or discs is provided by direct mounted fans in the slipstream.

Figure 6 shows a De Havilland Beaver fitted with boom and nozzles which was used by the R.R.I. in the experimental defoliation trials carried out between 1952 and 1956. This unit gave an output of one gallon per acre when swathes were flown at intervals of one chain at 90 m.p.h. The boom with nozzles was later replaced with rotary brushes which gave greater scope for changing the characteristics of the spray, the output per acre, and for securing a narrower variation in the range of drop sizes.

Figure 6. A D.H. Beaver aircraft fitted with spraying gear. Note the boom supported from the wing; the special nozzles and the circular outline of the 200 gallon tank in the fuselage.

Superior Processing Rubbers

The complete patent specification submitted by the R.R.I. on the method of producing these rubbers has finally been accepted by the British Patent Office. This specification which has the number 803013 was opened to public inspection on 15 October 1958.

In the meantime production of this form of rubber has reached a monthly total of 200 tons. This includes all three varieties i.e. SP RSS, SP ADS and SP pale crepe. The estates so far involved in the production of these rubbers are Sepang, Prang Besar and Sungei Mahang (Agents: Harrisons & Crosfield Ltd); East Asiatic Company Factory, Taiping and Alma Estate (Plantation Agencies Ltd). The demand for this new type of rubber is increasing and more and more advantages in its use are being discovered by manufacturers. It is earnestly hoped that many more estates will undertake production of SP rubbers.

Every help in the form of specialised assistance by the R.R.I. will be provided during the initial stages of production. The process is simple to operate but it is necessary to obtain a formal licence from the Board of the R.R.I. before undertaking commercial production. Representative samples of production lots are required to be sent to the R.R.I. for approval before sale as SP rubbers. This stipulation is to ensure that only SP rubber conforming to specification reaches the market, which could be jeopardised by supplies of inferior material.

A REMINDER

SP rubbers are not sold according to International Grades. Under the conditions of our licence, SP rubbers are so far allowed to be sold only as SP RSS, SP ADS and SP pale crepe with no further distinctions as to No. 1, 2 or 3. SP rubbers being premium grade materials should only be produced under carefully controlled conditions. These rubbers will therefore necessarily be clean and free from blisters, specks, mould, rust and foreign substances. The presence of bubbles in SP sheets do not, in any way, affect its technical properties and should therefore be ignored. Similarly experience has shown that for most purposes no harmful effects result if the texture of SP pale crepe is a little less fine than that of International Type I pale crepe. In consequence, only a small quantity of off grades SP sheet or crepe should be produced under normal factory conditions. These should either be sold locally or on sample.

We earnestly hope that producers will cooperate with us in respect of these conditions.

SP BROWN CREPE

A new grade of SP rubber known as 'SP brown crepe' is now going through the development stages at the R.R.I. Experiment. Station Factory. SP brown crepe is made from scrap rubber by a special process for which the R.R.I. has already applied for patent protection. It is hoped that this process will become available to producers in the near future, when licences will be issued to those wishing to operate it. Further announcements will be made when the process is ready for commercial development.

SP MASTERBATCH

To meet the demands of manufacturers for conferring SP characteristics on other grades and mixtures of grades of rubbers,

the R.R.I. has developed an SP masterbatch. This masterbatch, when mixed dry with any type of rubber in suitable proportions, will confer SP characteristics on the blend. The material is now undergoing evaluation both in Malaya and in the United Kingdom. Further development work will probably be required before the new process is ready for trial at commercial production level. An article describing both this process and that for SP brown crepe will be published shortly in the R.R.I. *Journal*.

Correspondence

SPRAYING AGAINST S.A.L.B.

I have read with considerable interest the article 'Spraying Machinery for Estate Use' which appeared in *Planters' Bulletin 36* and in which are described the types of hand-and power-operated sprayers used on the R.R.I. Experiment Station in routine treatment of hevea diseases both in the nursery and in the field.

In this connection your readers may be interested in the photograph that I took in December 1957, of a portable power-operated sprayer in action against *Dothidella ulei* – the causal agent of South American leaf blight – in a seedling nursery on Pirelli's Oriboca Estate near Belem, Para, Brazil. The seedlings were nine months old at the time of my visit.

The demonstration of spraying with colloidal copper was arranged for my benefit by the Director of the Pirelli Plantation, Dr Th. G.E. Hoedt, whom some of your readers may remember before the last war as Director of the West Java Proefstation (now the Proefstation der Centrale Proefstations Vereniging).

The petrol engine is on the operator's back; the engine controls and spray fluid reservoir are in front, as shown in the photograph.

E.D.C. Baptiste

Director

Rubber Research Institute of Ceylon

Dr Baptiste's informative photograph depicts a situation in which the power-operated knapsack mist-blower is an invaluable tool. Nurseries in areas where South American leaf blight occurs need to be treated repeatedly with fungicides. The machine illustrated economises on labour and repays its won capital cost when in regular use. A colloidal copper fungicide is ideal, as it does not clog or settle out, and is deposited on the leaf as fine droplets which are very effective against fungal spores. Figure 4 on page 137 of this issue shows a model of similar function. It is fortunate that no hevea disease in Malaya requires such intensive treatment. Dothidella ulei, the cause of South American leaf blight, is confined to the American tropics.

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